regular discharge will be increased with an increase in applied potential up to a limit above which a further increase in potential will cause a constant discharge with little or no rhythmic activity. The appearance of rhythmic activity following stimulation during sleep is explained by assuming a low level of cortical excitatory state during sleep which is brought up to a level permitting rhythmic activity. The level of cortical excitatory state may be already up to such a level in the waking state that a further increase with stimulation causes the excitatory state to pass beyond the level permitting rhythmic activity, perhaps, into the region of constant discharge. Furthermore, it appears as a general rule that the amplitude of brain potentials decreases with their frequency, which occurs also in the relaxation oscillator of proper RC constants.

Variations in the bioelectric activity of brain cells could be due to (1) changes in physico-chemical processes within the cells, such as accompany toxic agents, circulatory changes, temperature, etc.; (2) differences in the physical structure of the cell, as in normal cyto-architectonic structure and pathological cell growth, and (3) changes in the anatomical and function association of one group of cells with another. All these factors, plus the specific effect of centripetal nerve impulses themselves, may affect the cortical excitatory state, which may be considered a major factor in controlling rhythmic activity.

HERBERT H. JASPER
BROWN UNIVERSITY AND
THE EMMA PENDLETON BRADLEY HOME

THE MOISTURE RELATIONS OF PECAN LEAVES

IT has frequently been noted by those familiar with the growth of pecan trees that under orchard and field conditions pecan leaves do not wilt. In periods of drouth leaves lose their "freshness" but do not actually wilt. As the drouth period progresses little change occurs in the appearance of the leaves until seemingly when a critical point in moisture deficit arrives. Then a "drouth necrosis" of sharply marginated areas of the leaflets occurs. This is frequently followed by an abscission of leaflets and leaves. Recently, data have been obtained which may have a bearing upon this phenomena and upon the relation of soil moisture to leaf functioning and to the formation and accumulation of storage carbohydrates in the tree.

In endeavoring to influence the vegetativeness of trees, their carbohydrate storage and the "filling" and maturity of nuts at harvest time, plots varying widely in soil moisture content have been maintained. In the wet plots soil moisture approaches field capacity; in the dry plots moisture is below the wilting point in the first two feet and below optimum at lower depths. Leaves in the drier plots are smaller, thicker, less green and lacking in "freshness." A typical margined "drouth necrosis" of many leaves has occurred, but there has been no wilting. It was presumed that the moisture content of leaves from the wet and dry plots would be significantly different. We have been surprised to find, from many determinations, that the per cent. of moisture in mature leaves is nearly constant, regardless of differences in soil moisture when conditions for maximum transpiration obtain; *i.e.*, between the hours of one and five P.M. on days of maximum brilliance, high temperature and low humidity. During the night or on cloudy and humid days, the moisture content of leaves increases slightly and the increase is greatest in leaves from the wet plots. Subsequent investigations have included trees growing in commercial orchards with highly variable soil moisture.

Using the familiar cobalt chloride method the transpiration of leaves in the wet and dry plots has been studied. No attempt has been made to measure the relative rate of transpiration in the two. However, leaves which show any appreciable drouth necrosis transpire very slowly, if at all, but healthy leaves under wide extremes of soil moisture transpire freely. Apparently a considerable degree of drouth may occur before transpiration ceases or before CO_2 entrance into the leaf and the interruption of photosynthetic processes occurs. This latter has been best shown by microscopic studies which clearly reveal a greater amount of starch and hemicellulose cell wall thickenings in shoots from the dry than from the wet plots. Conversely, the nitrogen content in leaves and other tissues is reduced in the dry plots.

With a reduced nitrogen content and with photosynthetic action but slightly if at all impaired conditions favoring carbohydrate storage are accomplished through moderate drying of the soil. It is suggested that in soil moisture control may lie an important means for regulating the formation and utilization of carbohydrate reserves in the tree. These latter are believed to be of prime importance in that in late summer they are probably converted to sugars, fats and oils and hence influence the filling and quality of nuts at harvest.

ALTON H. FINCH
CLIFTON W. VAN HORN
UNIVERSITY OF ARIZONA

THE "FLIGHT" OF FLYING FISH

IN a recent article in SCIENCE (83: 80, 1936), C. A. Mills discusses the propulsive power used by flying fish. As a Naval Reserve officer I have, during the last twelve years, spent many hours at sea on various naval vessels, mostly destroyers, in the waters of Southern California, where the flying fish *Cypseturus Californicus* abounds. In view of the controversial nature of the supposed "flight" of these fish, I have repeatedly and carefully observed their movements from the advantageously low position afforded by smaller craft. I have also observed them at night under strong lights when netting or spearing them at the ship's gangway for the mess.

It appears quite certain from my observations that the chief impetus for the flight is derived under water, apparently the major portion of the thrust coming from tail movements. When swimming under the light the pectoral fins are little used and mostly folded. Occasionally, when apparently stupefied by the light the fish lie with both pectoral fins half spread in a peculiarly relaxed position. Under the light I have never observed any active use of the pectoral fins in swimming. A single powerful thrust may be given in folding the fins from the open position at rest. In daylight flights as the fish leaves the water, in most but not all cases, as stated by Mills, its wings *appear to move* as if in an effort to fly. The motion is not long continued, only four to six or at most about 20 vibrations being accomplished. While such fin movements are in the nature of flying movements the fins are awkwardly handled and seem woefully inefficient and inadequate when compared to the motion of the wings of birds in flight. The wing motions are more in the nature of the bat's wing action, but vastly slower and of relatively small amplitude. It is my distinct impression that these apparent flying motions are in part a consequence of the body motions in swimming which are sustained after emergence from the water and must be readjusted in adapting their movements to the new medium. There is no question but that a large part of the effective effort of this wing motion is expended in orienting the body and wings for the soaring flight which comprises 95 per cent. of the distance covered. It is not used in gaining altitude. There is also a possibility that the motions serve the purpose of disencumbering the fins of superfluous water in taking to the air. Doubtless the motion accomplishes several purposes at the same time, but it is very doubtful whether any momentum for the flight is gained in this way. Once the wind has been caught and the body oriented the flight is definitely a soaring flight with not the least indication of wing movement. This portion of the flight is much like that of the paper darts used by school boys, with, however, some steering action by wings and tail. The flight continues until the fish recovers from its alarm or until, owing to an improper start, it loses altitude. If the flight is to be resumed the fish, as it approaches the water, lowers its tail and with a series of powerful and rapid strokes of the tail in the water regains enough momentum for a continued flight. The motion of its pectoral fins is usually negligible or entirely missing in this new flight. In some cases the fish has been observed to renew its flight in this fashion three times after its initial "take off." The end of the flight is quite abrupt, the tail drops to act as a brake, and the wings fold as the fish strikes the water. The splash produced is confined to the body impact with the water. The flights appear to be conditioned by disturbances in the water, *i.e.*, the bow or hull of the ship or the ship's bow wave. The "take off" under water thus must be in a direction away from the position from which the disturbance comes. In most cases the flight therefore starts along lines radiating from the bow of the ship or at right angles to the hull. On emergence the direction of flight appears to be determined largely by the wind direction and the initial impulse, the latter being away from the disturbing agent. Since the flight is largely dependent on the wind it is clear that successful flights will be controlled by this factor. If the "take-off" occurs under unfavorable circumstances the flight terminates abruptly. Flights originating on the starboard bow have been observed occasionally to cross the bow and end well off the port bow and *vice versa* under proper wind conditions.

LEONARD B. LOEB
UNIVERSITY OF CALIFORNIA

FLYING FISH

THE recent article by Dr. C. A. Mills on "The Source of Propulsive Power Used by Flying Fish"[1] gives an interesting description of the method of regaining lost flying speed by dipping the tail into the water and lashing with it to attain the velocity for a fresh take-off. Having read of this maneuver, and observed it a number of times, I was surprised at the implication that this feature of the flight is not recognized in the literature of the subject.

In January, 1934, I made the voyage from Woods Hole to Panama on the oceanographic ship, *Atlantis*, in company with C. M. Breder, of the New York Aquarium, and other investigators. Mr. Breder had with him a large assortment of literature on flying fish[2] in which I read of the performance that is described by Dr. Mills. After the initial take-off, the fish glides till flying speed is lost, then dips his tail in the water and sculls with it till flying speed is again

[1] SCIENCE, 83: 80, 1936.

[2] R. E. Dowd, *Aerial Age Weekly*, January 10, 1921, pp. 464–465. W. E. Shoulejkin, *Int. Rev. d. ges. Hydrobiol. u. Hydrographie*, 22: 102–110, 1929. C. M. Breder, Jr., *Copeia*, 4: 114–121, 1930. C. L. Hubbs, *Papers Mich. Acad. Sci., Arts and Letters*, 17: 575–611, 1933; (see also, *Ann. Rept. Smithsonian Institut. for 1933*: 333–347, 1935).